# Armed Forces College of Medicine

## AFCM

# Blood Pressure Regulation

By

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# INTENDED LEARNING OBJECTIVES (ILO

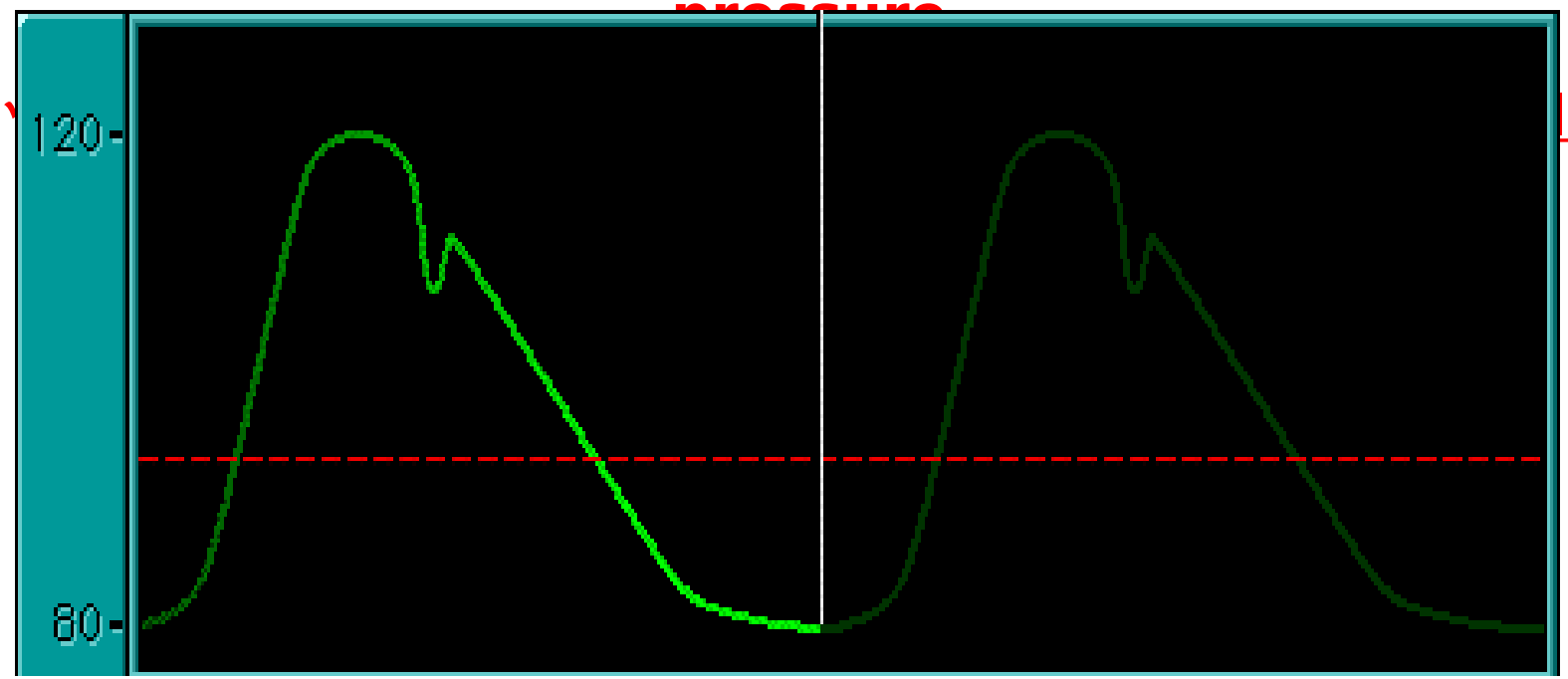
**By the end of this lecture the student will be able to:**

- ✓ **List factors that affect arterial blood pressure (ABP)**
- ✓ **Describe mechanisms by which ABP is regulated**
- ✓ **Indicate the relationship between ABP, cardiac output (CO), and total peripheral resistance (PR) & predicts how ABP will be altered when CO and/or PR changes**
- ✓ **Given arterial systolic & diastolic pressures, estimates mean arterial pressure**
- ✓ **Indicate the relationship between pulse pressure, stroke volume, and arterial compliance & predicts how pulse pressure will be changed by changes in stroke volume, or arterial compliance**

# Arterial Blood Pressure

**During each cardiac cycle, aortic pressure shows regular changes**

- ✓ The maximum pressure is about **120 mm Hg = systolic pressure**



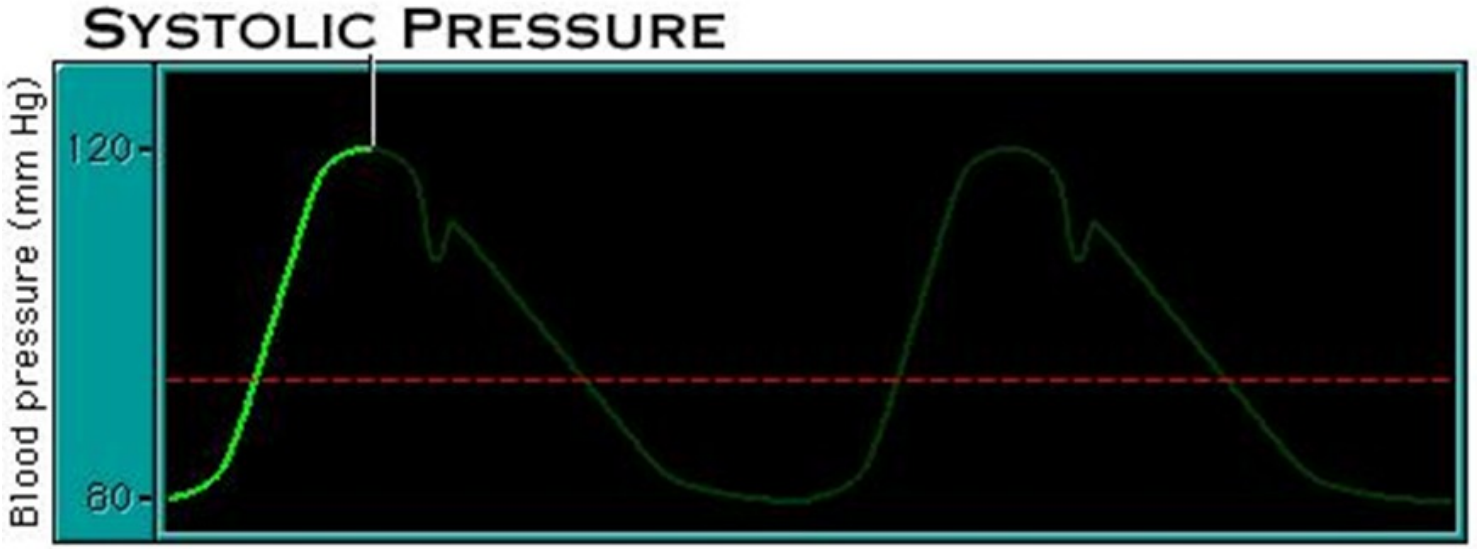

**Arterial Pulse curve**

# Arterial Blood Pressure

**Definition:** : It is the lateral force produced by the blood on the arterial walls

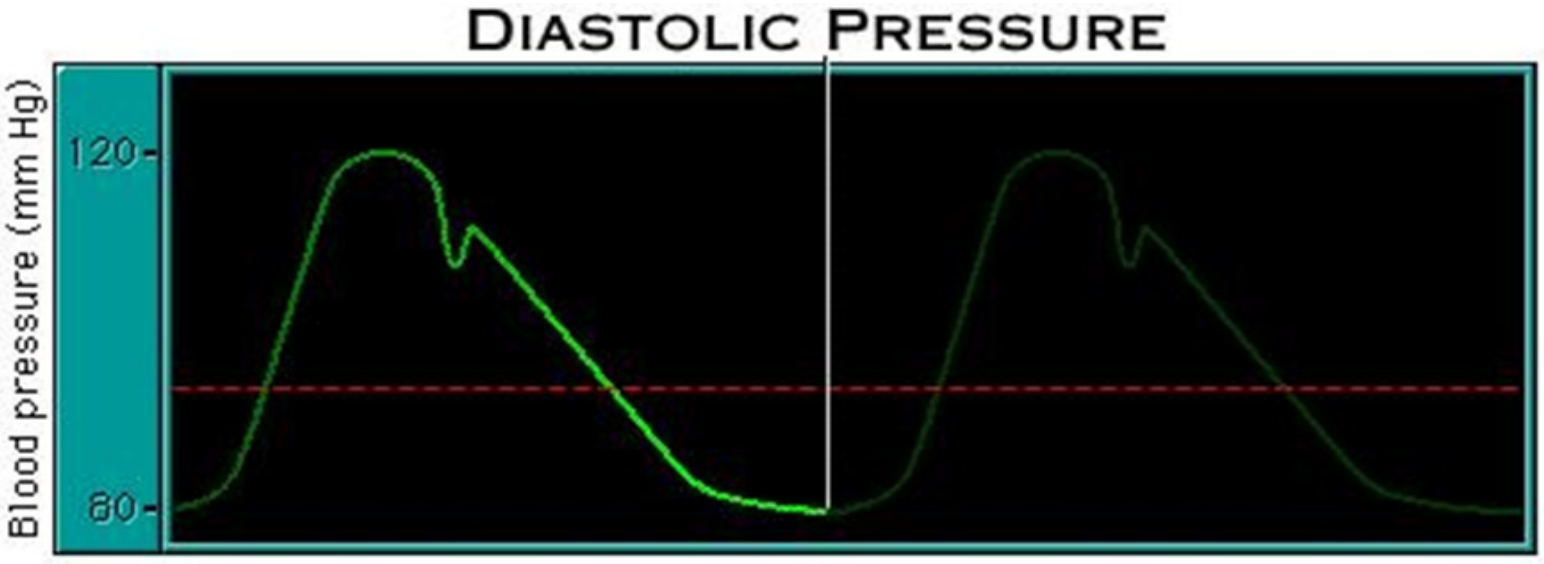
- ✓ It increases to a maximum (*during systole*) = **Systolic blood pressure**
- ✓ It decreases to a minimum (*during diastole*) = **Diastolic blood pressure**

# Arterial Blood Pressure




* It is the **maximum** pressure exerted by the blood against the arterial wall
* It occurs during **ventricular systole**
* Normally: **90 – 140 mmHg**
* Average: 120 mmHg

# Arterial Blood Pressure



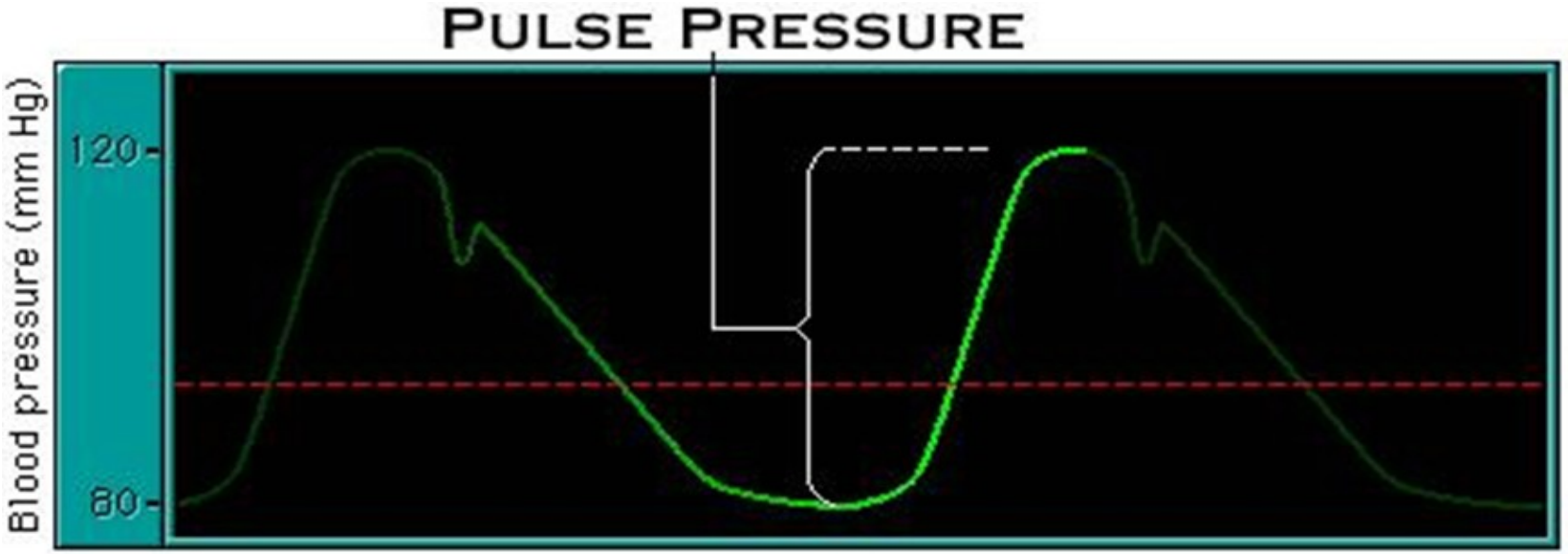

**It is the minimal pressure exerted by the * blood against the arterial wall**

*** It occurs during ventricular diastole**

**Normally: 60– 90 mmHg ***

*** Average: 80 mmHg**

# Arterial Blood Pressure



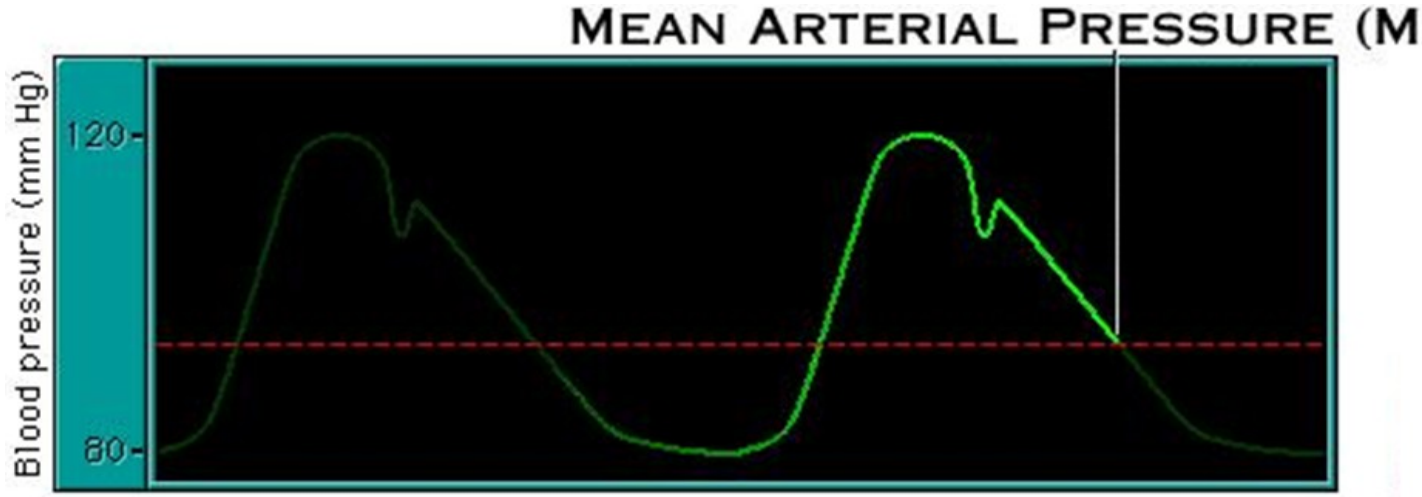

**It is the difference between systolic & * diastolic blood pressure**

*** Pulse pressure= Systolic pressure - Diastolic pressure**

*** Normally: About 30-50 mmHg**

**120mmHg - 80mmHg = 40mmHg**

# Arterial Blood Pressure




- **It is the average pressure inside the arteries during the cardiac cycle**
- **It determines tissue blood flow**
- **As systolic time is about 1/3 cardiac cycle & diastolic time is 2/3**
  - **So, MAP is nearer to diastolic pressure**

***It is calculated as: Mean ABP = diastolic pressure + 1/3 of pulse pressure***

***(80) + (1/3 X 40)***

# Factors that affect ABP

## ysiologic variations in ABP

**Age**

**Infants** : 80/40 mm Hg
**Children**: 100/65 mm Hg
**Adults**: 120/80 mm Hg……

**< 140 / 90 mmHg**

**Sex**

Below the age of menopause
**Women < men**

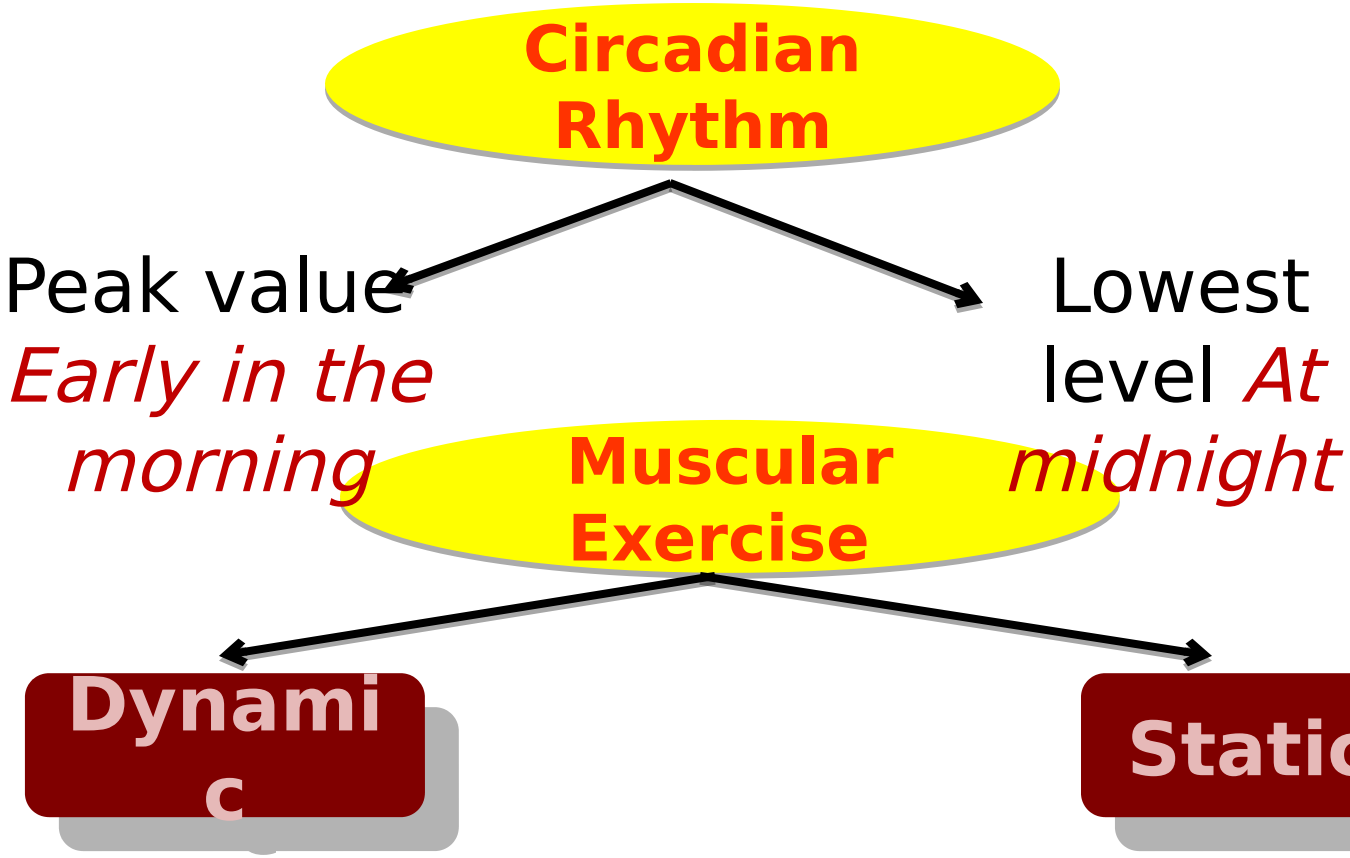
“↓Elasticity ”

**Emotions**

**Stress increases ABP**
*“White coat hypertension”*

# Factors that affect ABP

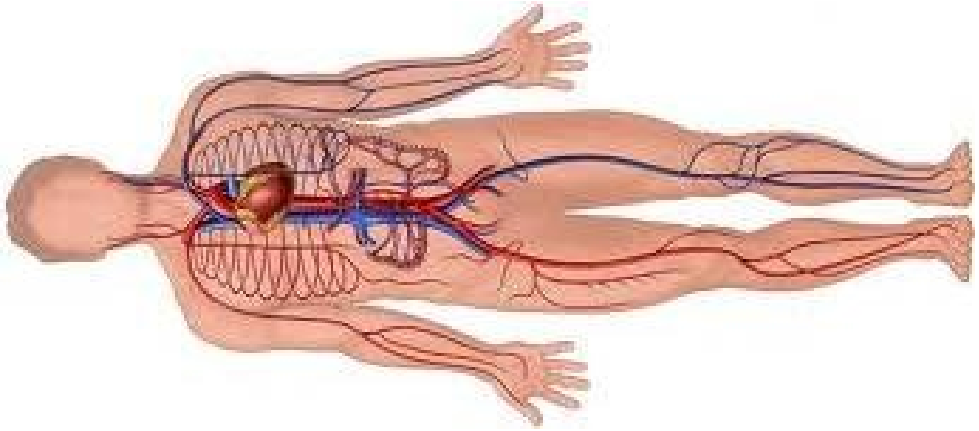
## ysiologic variations in ABP



# Factors that affect ABP

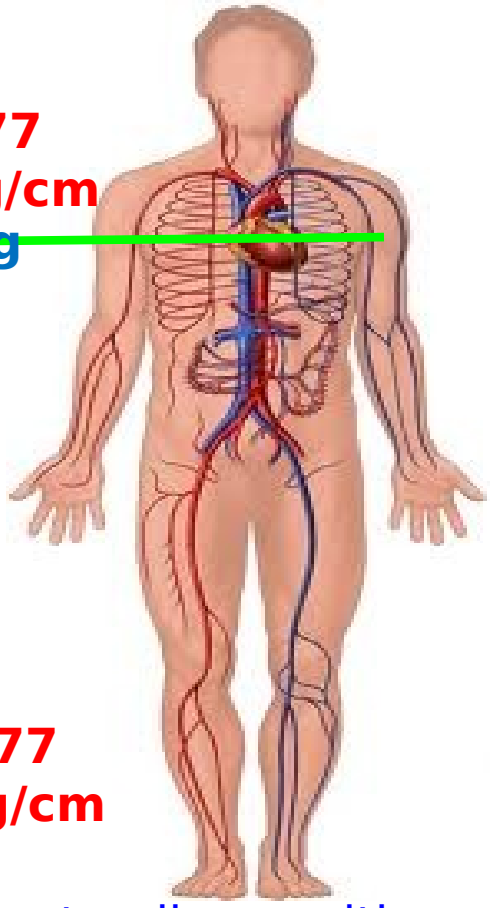
## ysiologic variations in ABP

**Effect of gravity on ABP**



When the subject is lying down

MAP in all major arteries is about 100 mm Hg when they are at the level of left ventricle



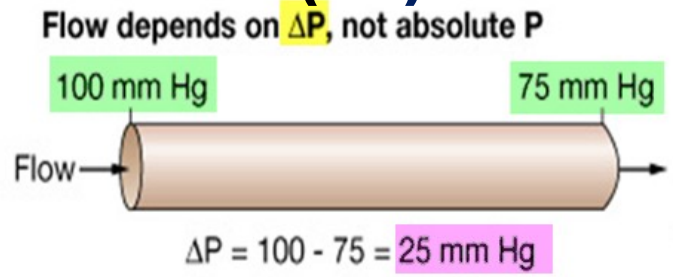

In standing position

✓ ABP above level of LV ↓ by 0.77 mmHg/cm above level of the heart

✓ ABP below level of LV ↑ by 0.77 mmHg/cm below level of the heart

# Factors that determine ABP

**Blood Flow α Arterial Pressure (ΔP)**



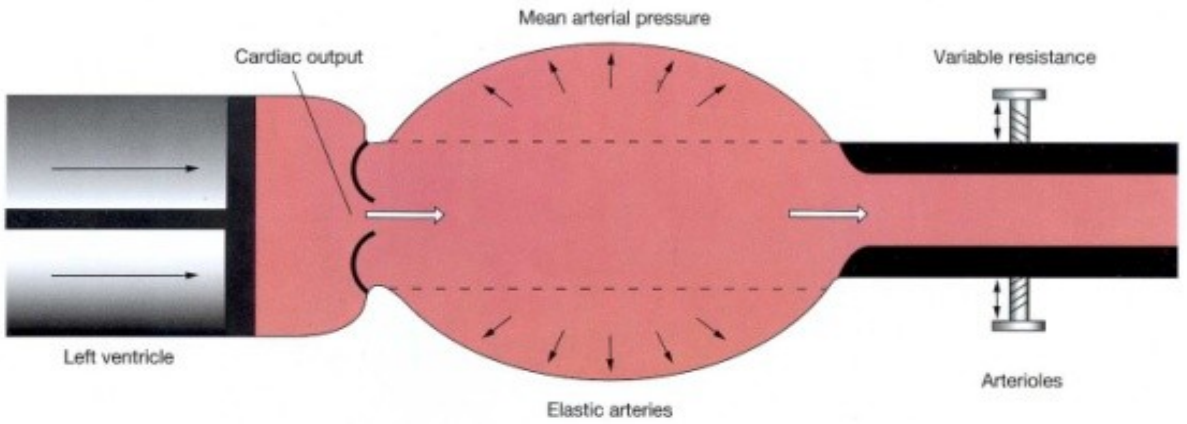

**Blood Flow α 1/Peripheral resistance**

**Blood Flow α ΔP /Peripheral resistance**

**Therefore: ΔP = Flow x Peripheral resistance**

| Arterial pressure (ΔP) | = | Cardiac Output (F) | x | Peripheral Resistance (PR) |
|---|---|---|---|---|

# Factors that determine ABP




**ABP = Cardiac output (CO) x Peripheral resistance (PR)**

**Cardiac output**

- **Stroke volume**
- **Heart rate**

**Peripheral resistance**

# Factors that determine ABP

## 1- Cardiac Output

- An increase in COP  Increases ABP
- A decrease in COP  Decreases ABP

COP = stroke volume x heart rate

= (SV) x (HR)

**An increase in SV raises mainly Systolic BP**

*with no significant change in diastolic BP*

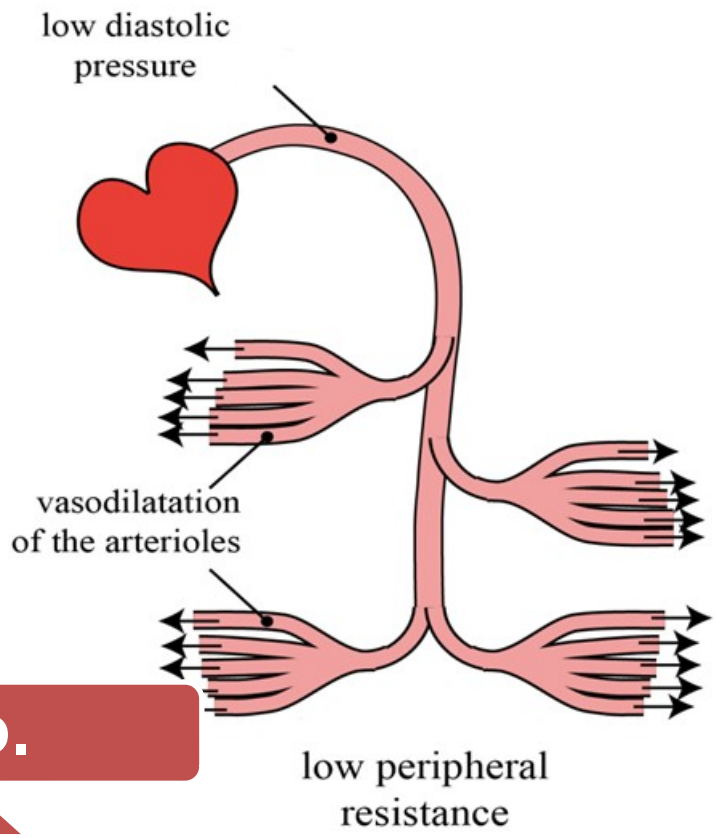
**An increase in HR raises mainly Diastolic BP**

*because less time is available for drop of pressure, as the diastole is shortened*

# Factors that determine ABP

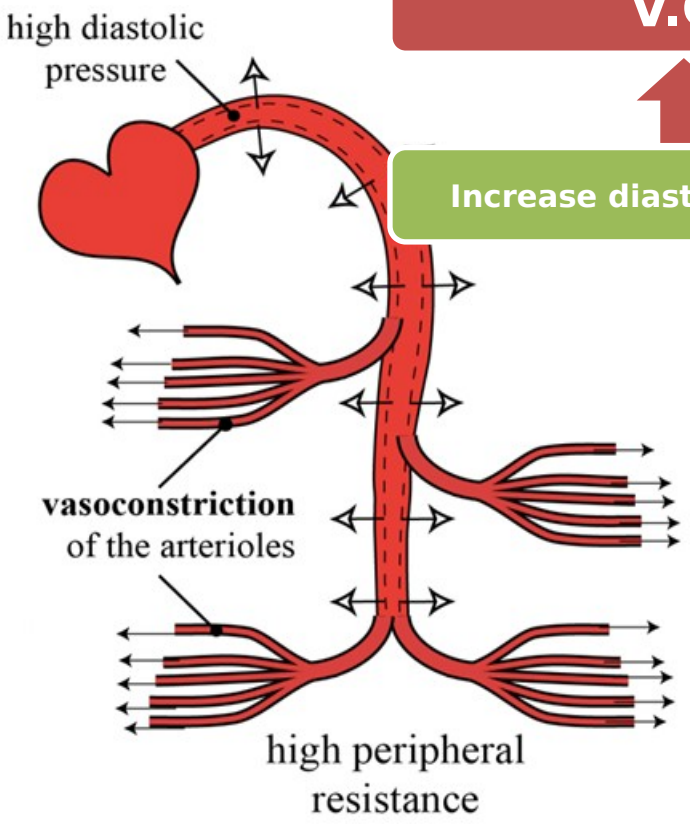
## Peripheral resistance (PR)

**Changes in PR affect mainly diastolic pressure**




**V.D.**

**Decrease diastolic pressure**




**V.C.**

**Increase diastolic pres**

# Arterial compliance

If arterial compliance decreases

e.g. due to atherosclerosis

**High systolic pressure**

**Low diastolic pressure**

*“ Because arteries are not able to distend enough to accommodate the stroke volume”*

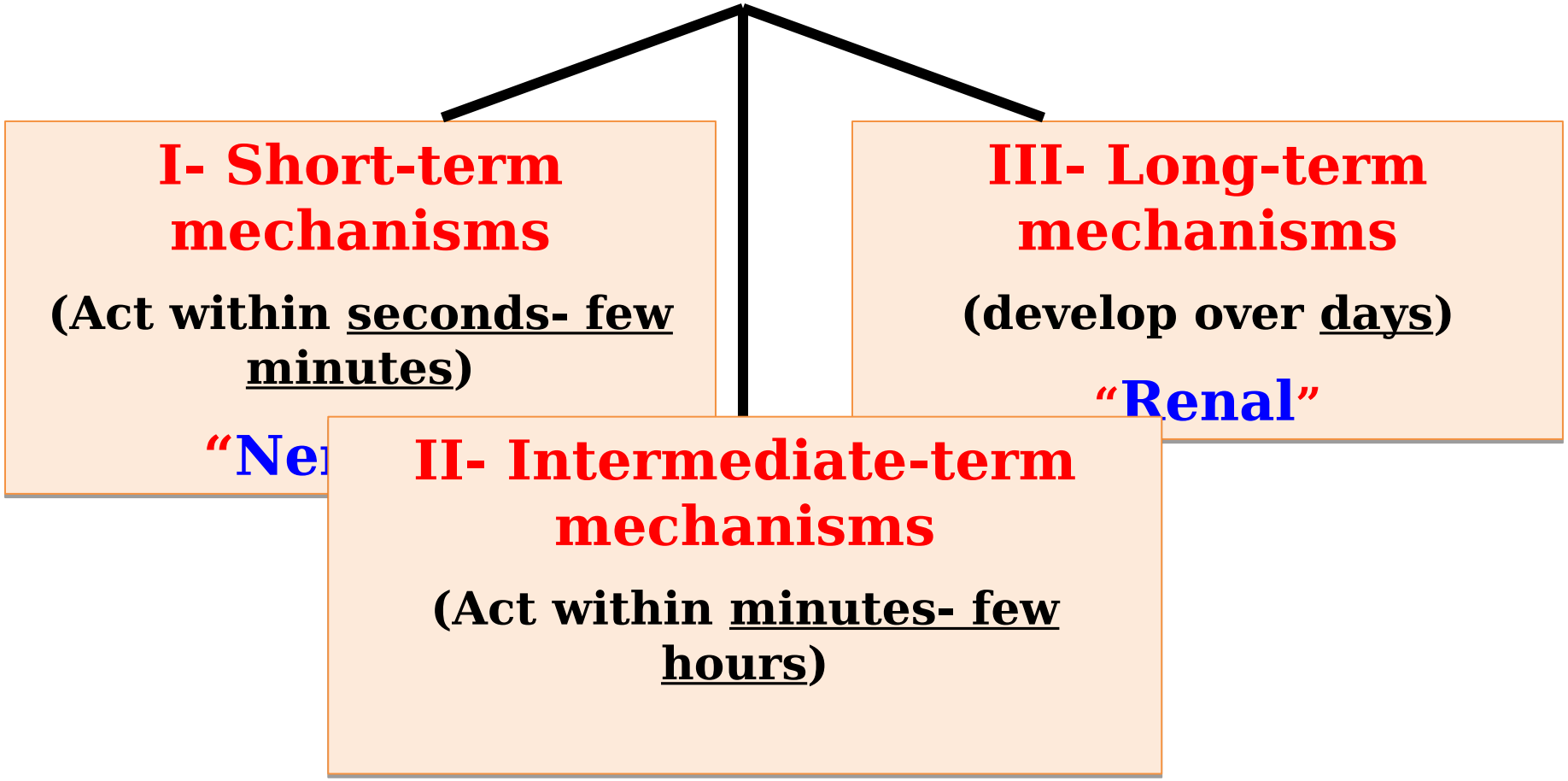
*“Because the ability of the arteries to recoil in diastole is decreased’*

**Pulse pressure therefore, increases**

# Regulation of Arterial Blood Pressure

# Regulation of arterial blood pressure

- ABP is regulated by **3** groups of mechanisms that differ in their time course



# Regulation of arterial blood pressure

## I- Short-term Regulation

- Potent & start acting within few seconds (**life saving**)
- **Rapidly adapting**
- They are mostly **nervous reflexes** **(affecting C.O.& P.R.) e.g.**

✓ **Baroreceptor reflex**

✓ **Atrial stretch receptor reflexes**

✓ **Chemoreceptor reflex**

✓ **Cushing's reflex (or reaction)**

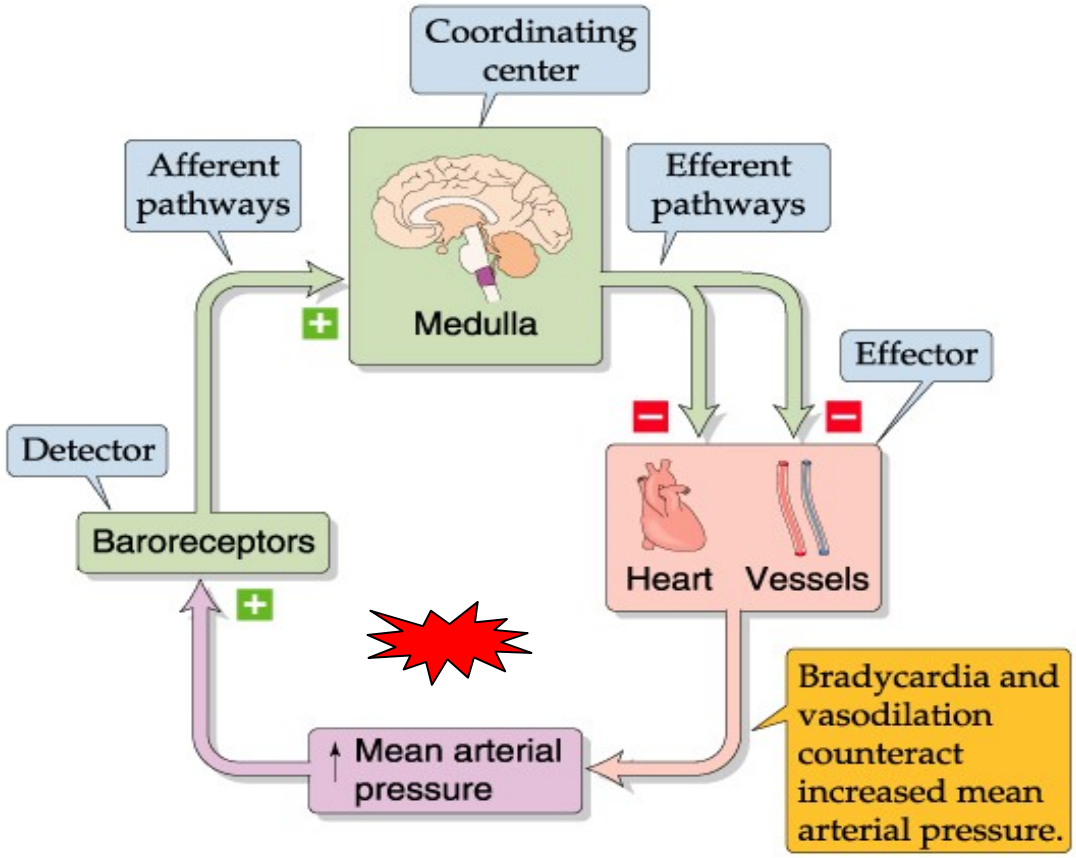
✓ **CNS ischemic response**

**(***In cases of severe reduction of the arterial BP***)**

# Mechanisms of ABP Regulation

## 1- Short-term mechanisms (NERVOUS)

### A. Baroreceptor reflex:

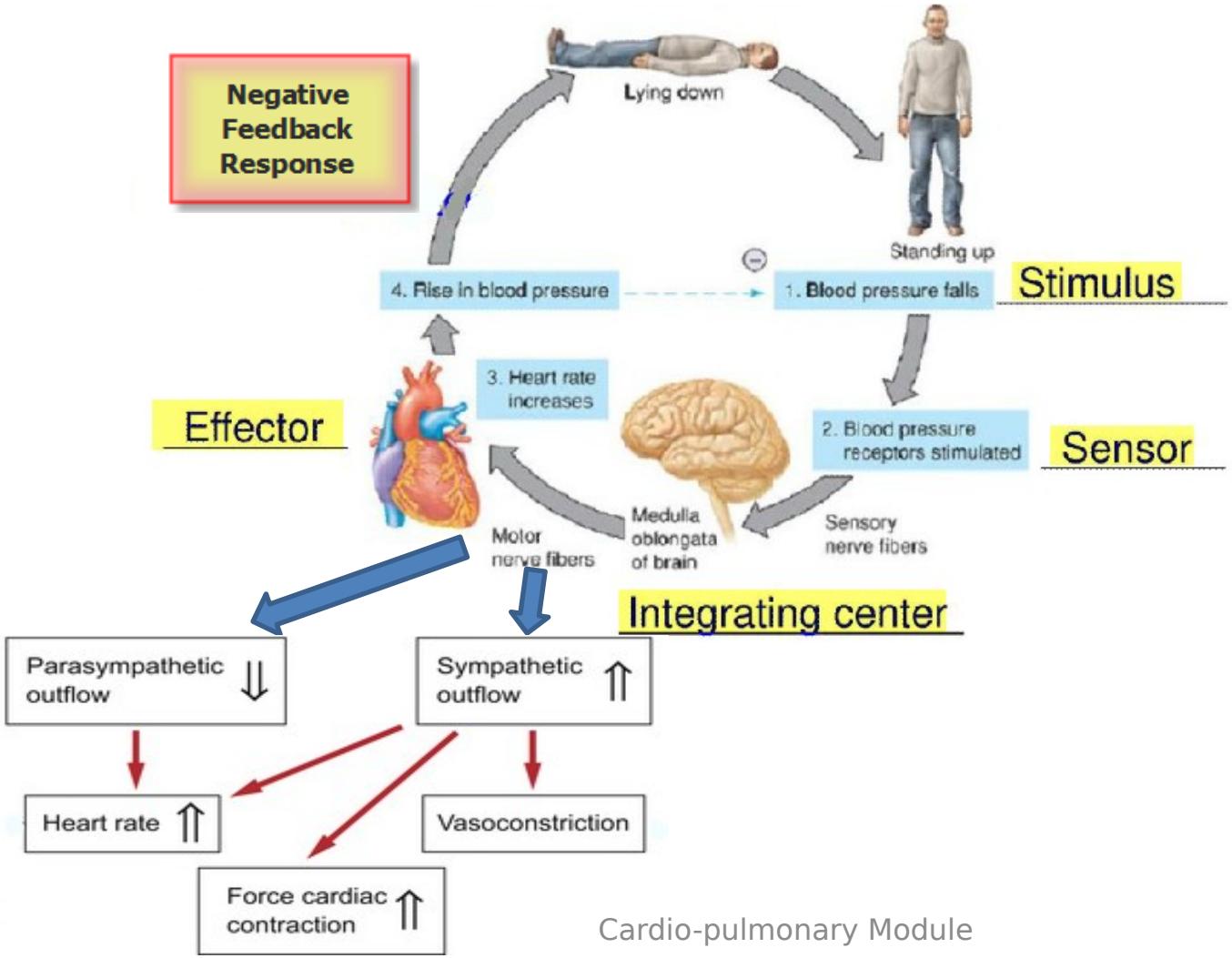


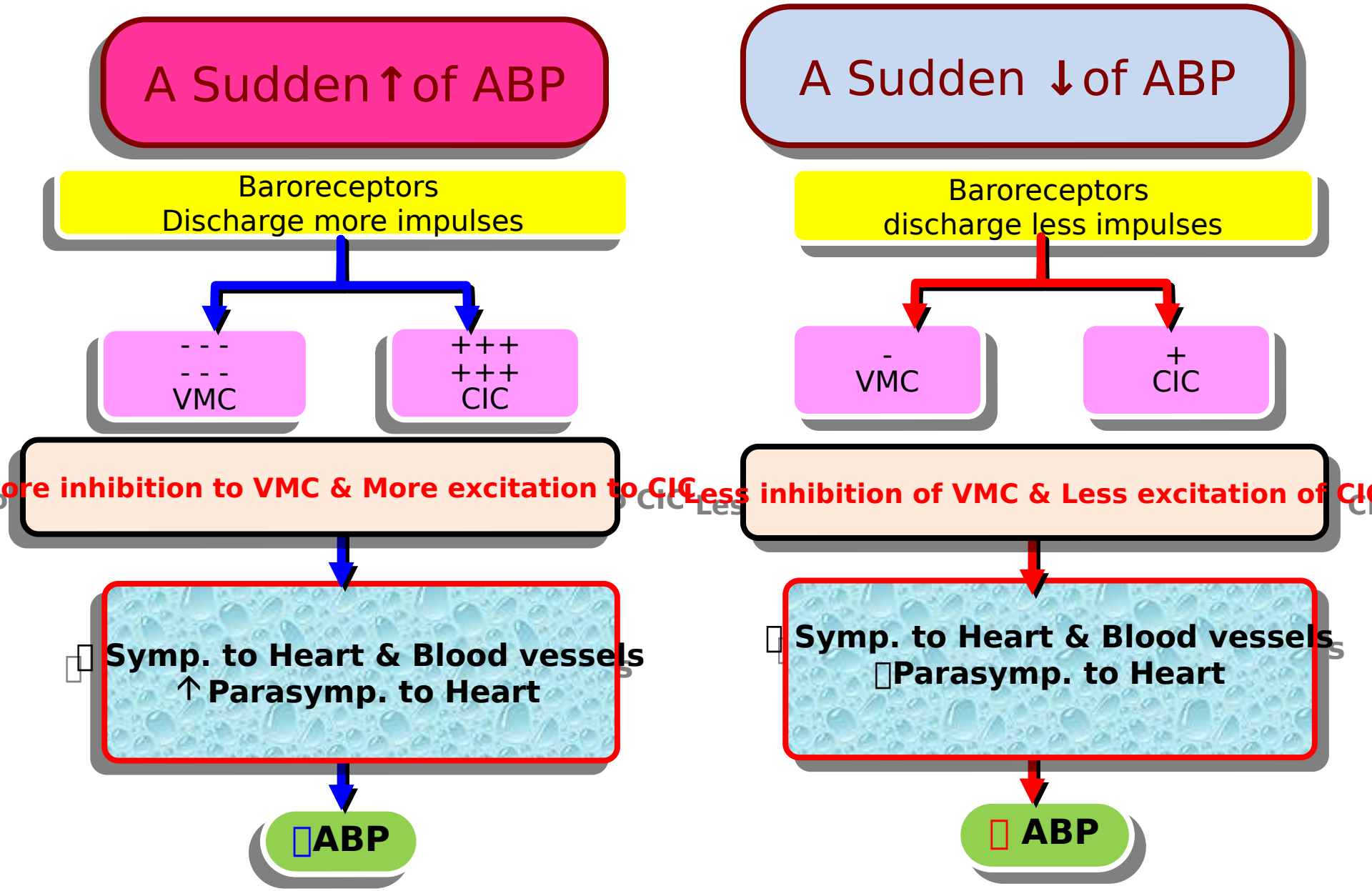
# Mechanisms of ABP Regulation

## A. Baroreceptor reflex:

**Acts to compensate for sudden changes in ABP**

*e.g. due to change in posture or hemorrhage*

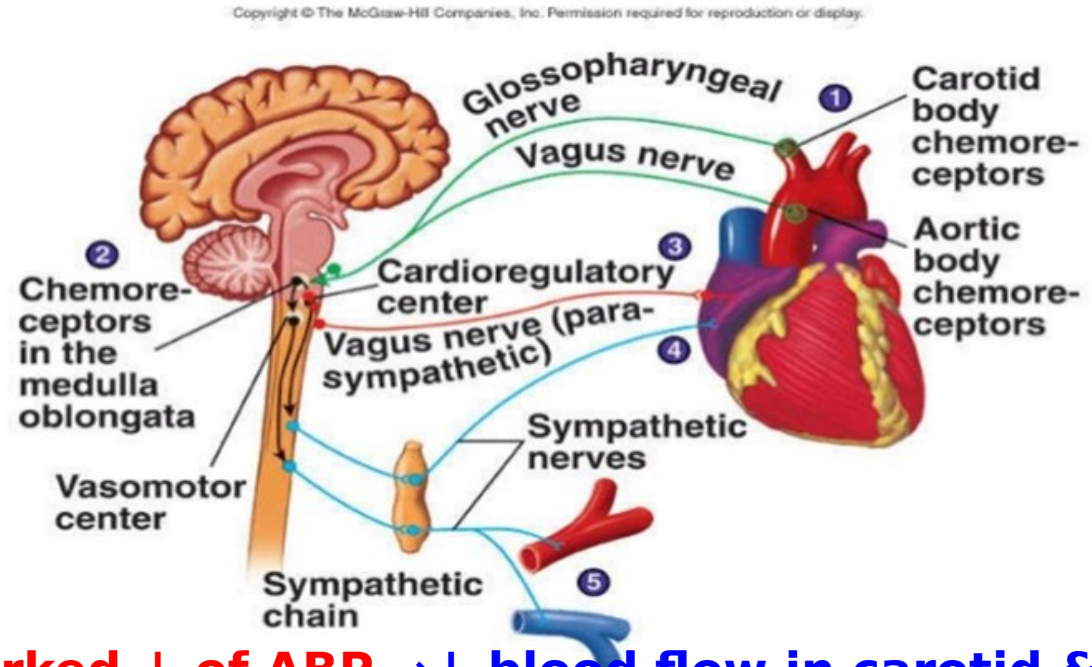



A Sudden ↑ of ABP
Baroreceptors
Discharge more impulses
- - -
- - -
VMC
+++
+++
CIC
More inhibition to VMC & More excitation to CIC
↑ Symp. to Heart & Blood vessels
↑ Parasymp. to Heart
↑ ABP
A Sudden ↓ of ABP
Baroreceptors
discharge less impulses
-
VMC
+
CIC
Less inhibition of VMC & Less excitation of CIC
↓ Symp. to Heart & Blood vessels
↓ Parasymp. to Heart
↓ ABP

# Mechanisms of ABP Regulation

## 1- Short-term mechanisms (NERVOUS)

**B reflex:**




**Marked ↓ of ABP →↓ blood flow in carotid & aortic bodies**

**→ hypoxia & ++ peripheral chemoreceptors → VMC ++**

**→ ↑ABP back toward normal**

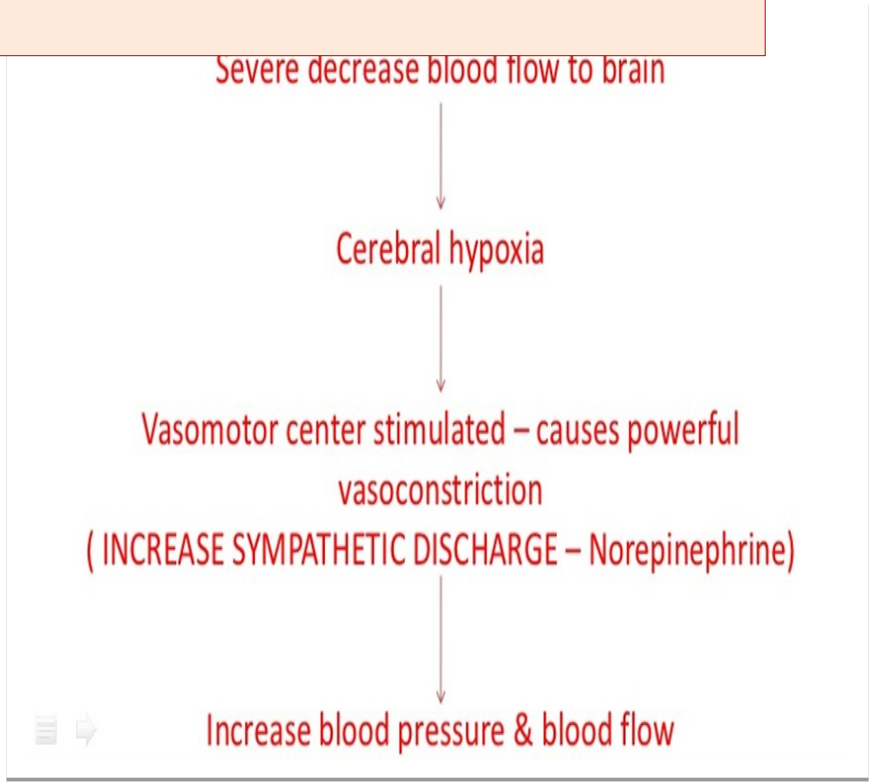
# Mechanisms of ABP Regulation

## 1- Short-term mechanisms (NERVOUS)

**C response:**

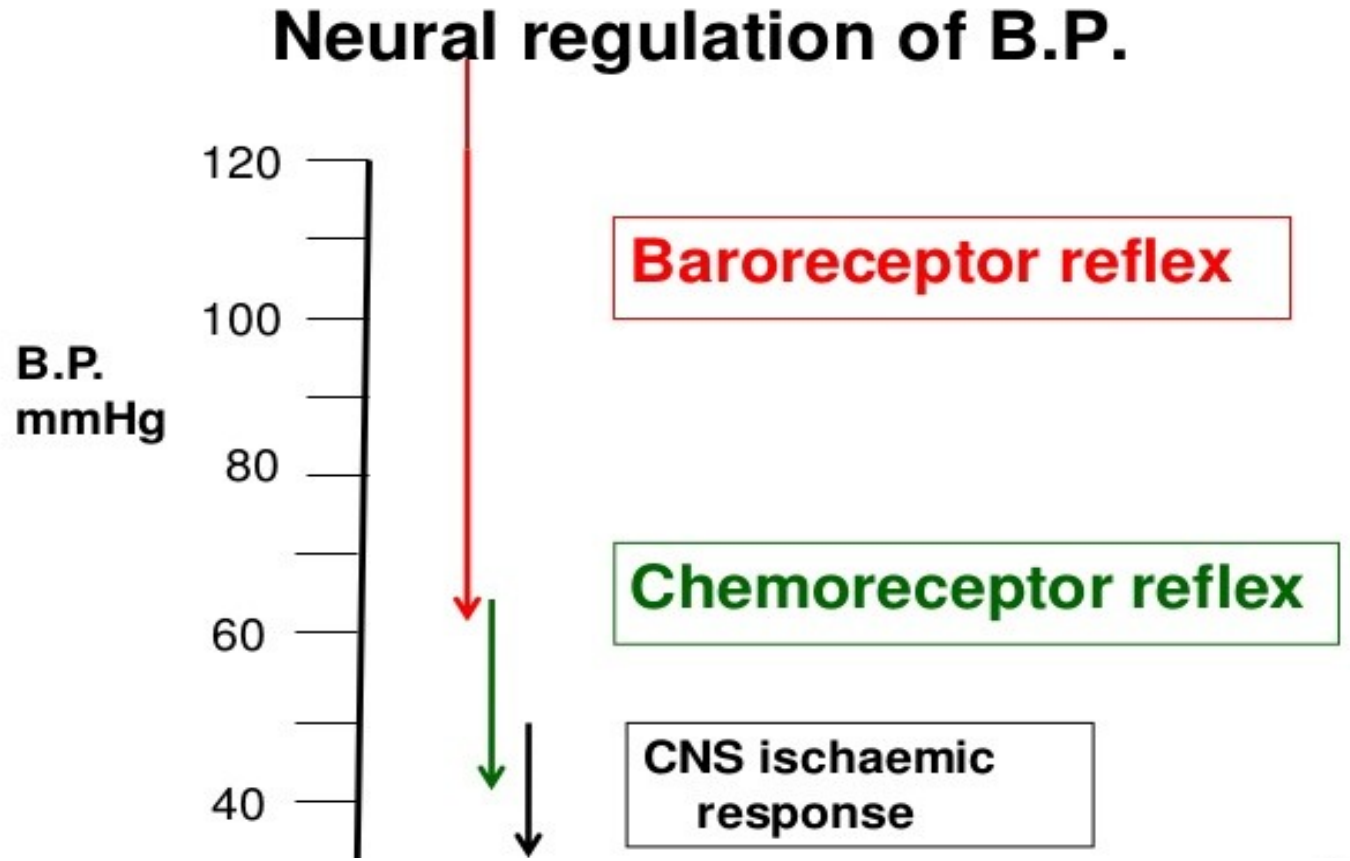
- ✓ *It does not become very active until ABP falls far below normal (≤60 mm Hg)*

- ✓ *It reaches maximum stimulation at pressure 15-20 mm Hg & called the "last ditch stand" mechanism for blood pressure control*



# Mechanisms of ABP Regulation

## 1- Short-term mechanisms (NERVOUS)



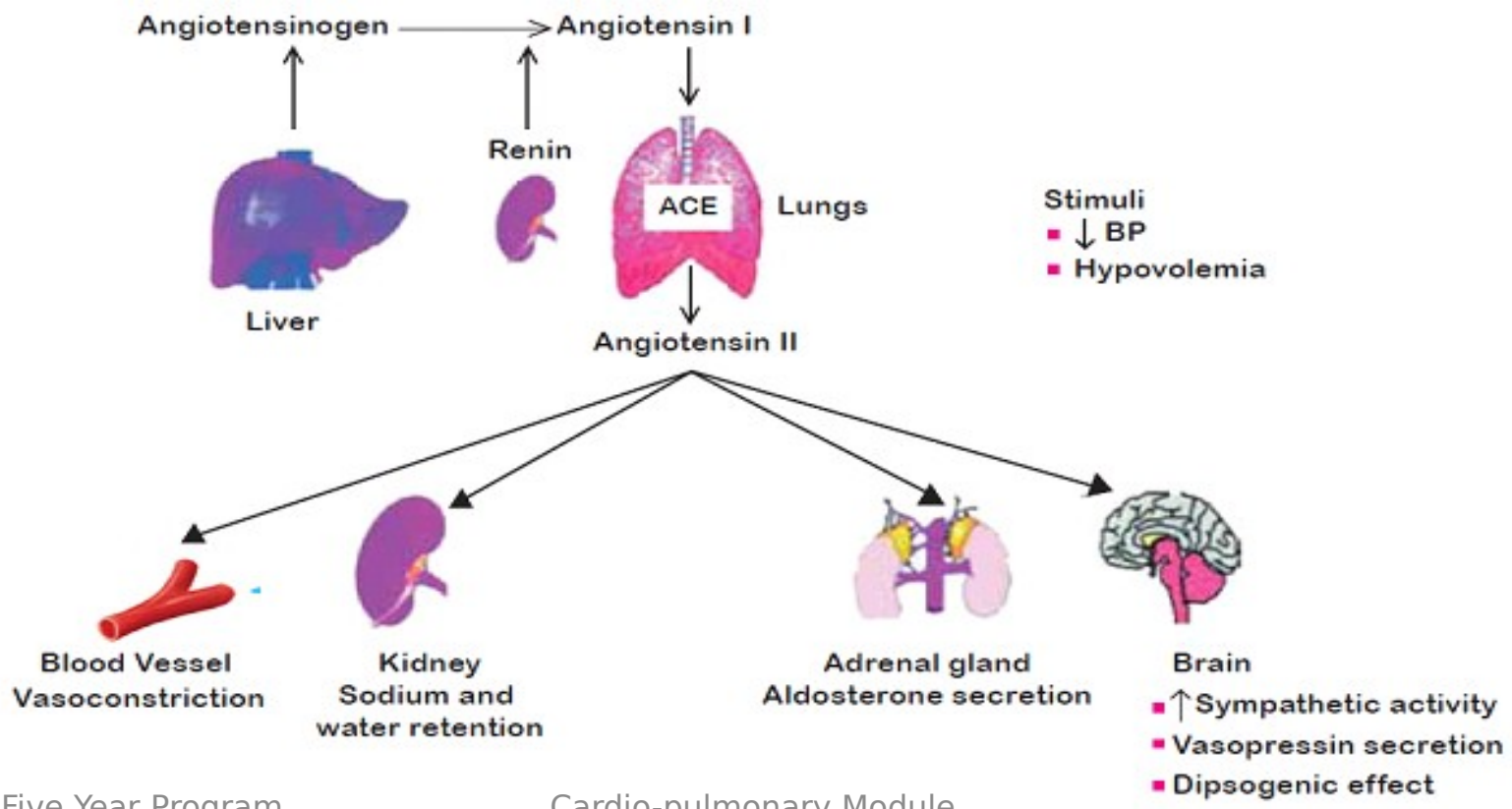
# 2- Intermediate-term mechanisms

- Acting within few minutes (Nervous mechanisms becomes less effective)
- Determined by blood volume, vascular capacity & resistance
- Mechanisms:
  - ✓ **Hormonal regulation**
    "Catecholamine, vasopressin & renin-angiotensin system"
  - ✓ **Capillary fluid shift mechanism**

# Mechanisms of ABP Regulation

## 2- Intermediate-term mechanisms (HORMONAL REGULATION)

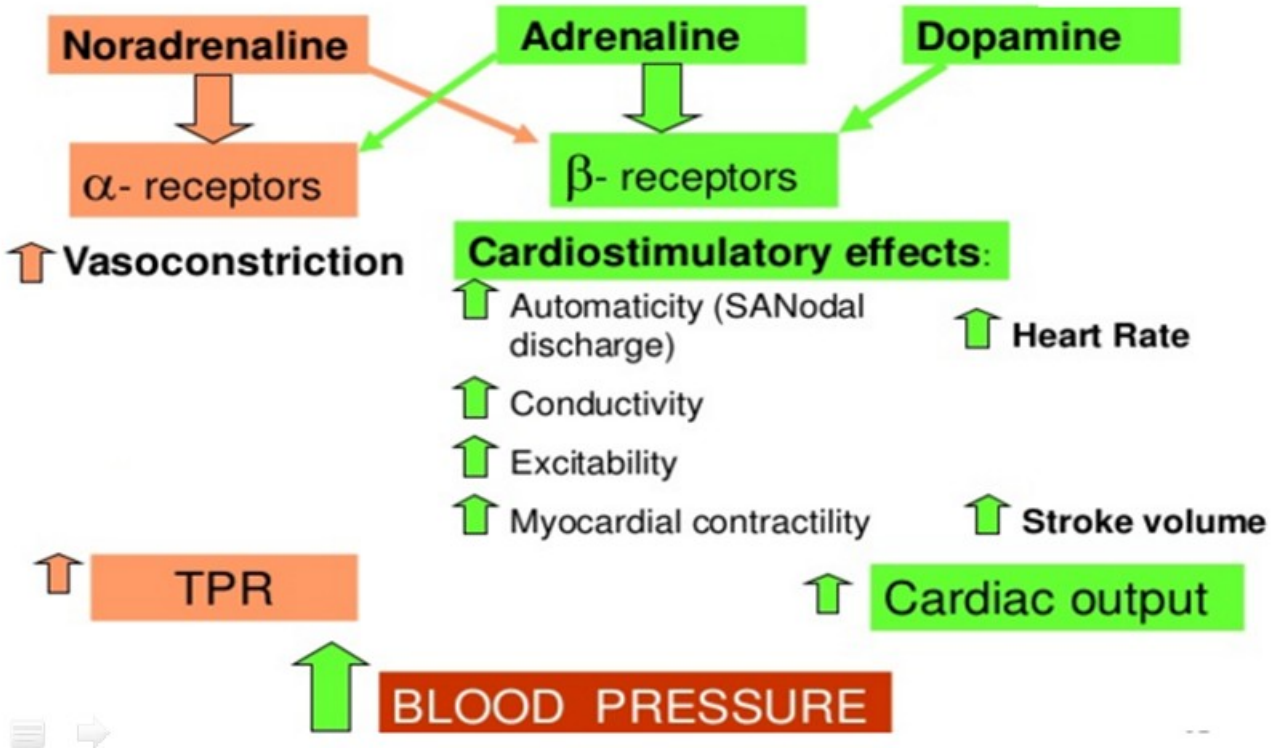
### A. Renin- Angiotensin



# Mechanisms of ABP Regulation

## 2- Intermediate-term mechanisms (HORMONAL REGULATION)

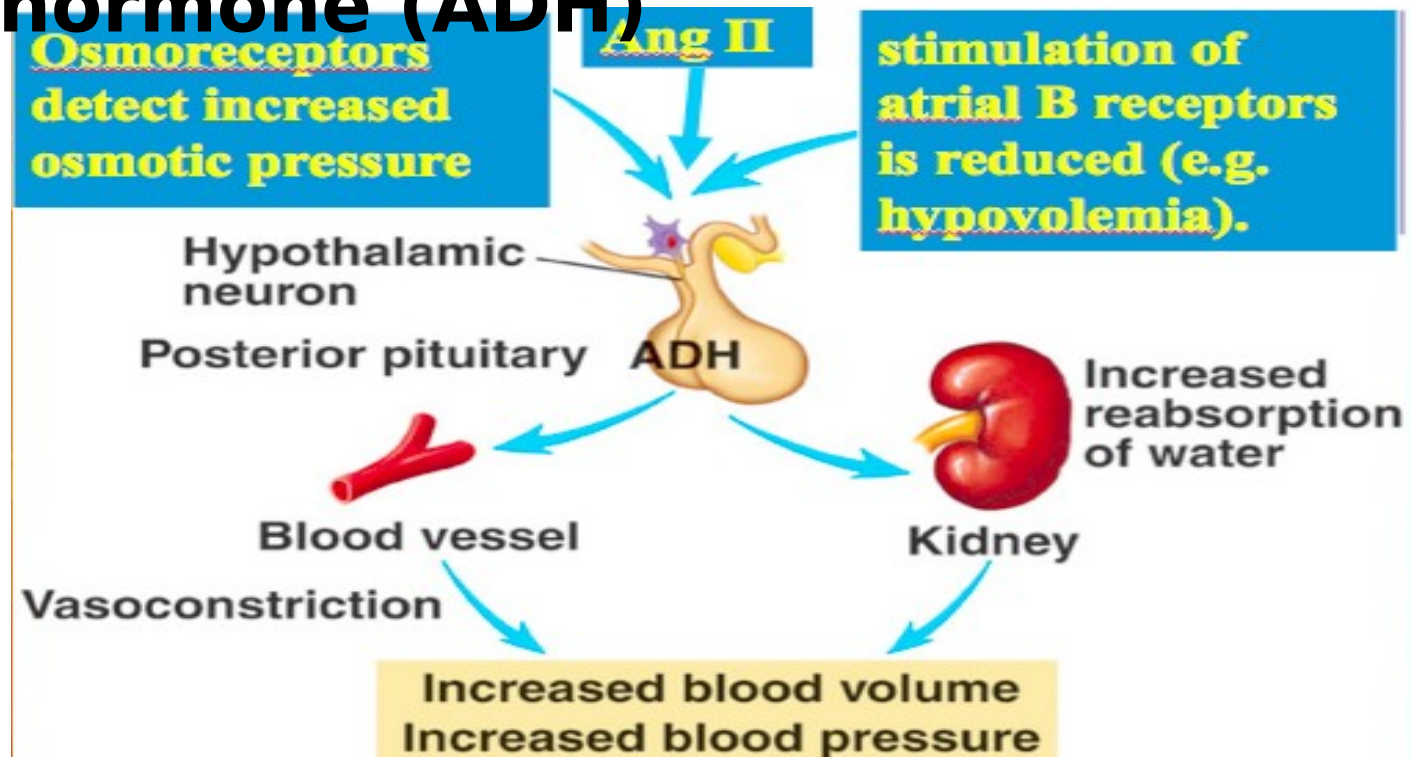
### B. Catecholamines



# Mechanisms of ABP Regulation

## 2- Intermediate-term mechanisms (HORMONAL REGULATION)

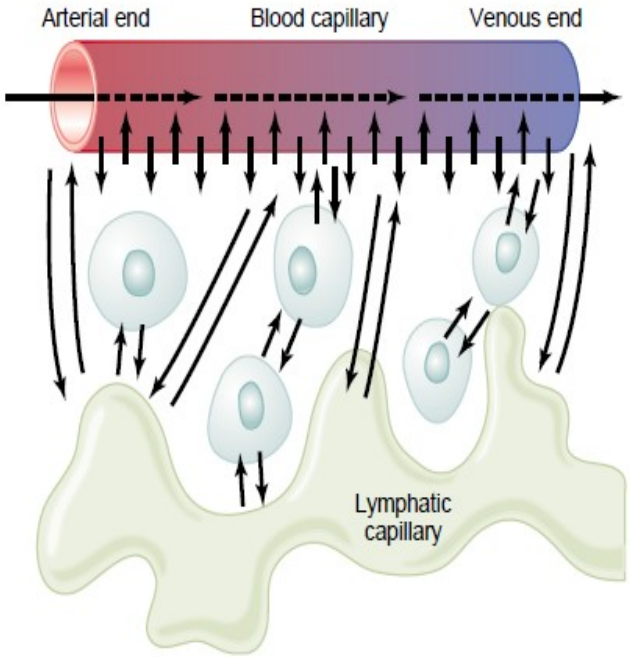
### C. Antidiuretic hormone (ADH)



# Mechanisms of ABP Regulation

## 2- Intermediate-term mechanisms (Capillary fluid shift mechanism)

- Increased **blood volume** increases **capillary pressure & fluid filtration into tissue spaces**




**So, blood volume will decrease** The rise in arterial blood pressure is minimized **& vice**

# Mechanisms of ABP Regulation

## 3- Long-term mechanisms

**(Renal-body fluids mechanism)**

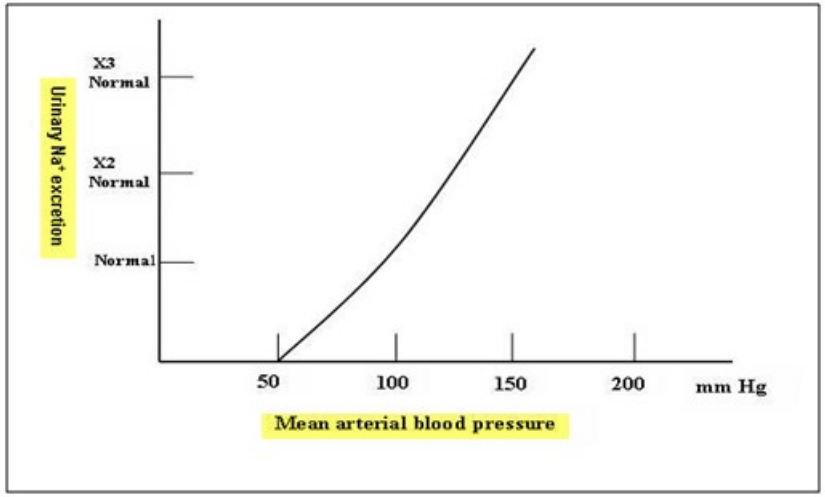
- It exerts its control on ABP through modifying renal excretion of water & salt
- It depends mainly on **kidney** & **hormones** acting on it to **change blood volume**
- **Mechanisms**:
  - ✓Renal pressure natriuresis
  - ✓Renin-angiotensin-aldosterone system
  - ✓Atrial natriuretic peptides (ANP) secretion
  - ✓Vasopressin secretion

# 3- Long-term mechanisms

## (Renal-body fluids mechanism)

Renal pressure natriuresis

When arterial pressure is elevated, renal excretion of $Na^+$ and water is increases




Decreasing ECF volume & lowering of arterial pressure

"This process continues until ABP decreases to normal level"

# Lecture Quiz

1. **An acute decrease in arterial blood pressure elicits which of the following compensatory changes?**
   a) Decreased heart rate.
   b) Decreased contractility.
   c) Decreased firing rate of the carotid sinus nerve.
   d) Increased parasympathetic outflow to the heart.
   e) Decreased mean systemic filling pressure.
2. **When the radius of resistance vessels is increased, which of the following is increased?**
   a) Systolic blood pressure
   b) Diastolic blood pressure
   c) Viscosity of the blood
   d) Hematocrit
   e) Capillary blood flow

# SUGGESTED TEXTBOOKS

1. **Guyton and Hall.** *Text book of Medical Physiology, 13th Edition*
2. **Ganong's** *Review of Medical Physiology, 25th Edition*
3. **Sherwood.** *Human Physiology From Cells to Systems, 9th Edition*


Thank You!